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정보기술을 활용한 생산과 마케팅 의사결정 조정

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An IT-based Coordination Support for Production and Marketing Decisions

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Abstract

This paper is concerned with the critical issue of allocating limited corporate resources among multiple products and between production and marketing functions of a functionally decentralized firm where the two geographically remote functions independently make decisions pertaining to their own decision-making domain. We attempt to demonstrate how IT can contribute to enhancing the quality of coordinating production and marketing functions from the perspective of resource allocation. To this end, we propose a prototype named ITBCS (IT-Based Coordination System) that works under LAN supported computing environments. We develop a comprehensive coordination scheme that can handle various cost functions for the resource constrained, multiple product case that has been little discussed in literature. A preliminary version of ITBCS has been implemented for a hypothetical situation where LAN electronically wires distributed marketing and production computing nodes. Managerial implications are also discussed.

Keyword : Production and marketing interface, Interfunctional coordination, Information technology, Mathematical programming

1. Introduction

Production and marketing are major functions that perform many of the primary activities in the value chain. As much as the two functions are related, they are in need of co-

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ordination of their decision-making processes and activities. Many studies have stressed that the coordination of production and marketing is essential to the improvement of corporate performance [5, 25, 31]. However, voluminous literature on the interface problems of production and marketing (PM) [7] indicates that their coordination is never an easy task. When coupled with the issue of allocating limited corporate resources among multiple products, the coordination tasks become even more challenging than ever.

The main objective of this paper is to show how a firm can use information technology (IT) to enhance its ability to allocate limited resources and to coordinate the interdependent decision-making processes of geographically dispersed production and marketing. Our view parallels that of Rockart and Short [30], in which they argue that IT's most important role is allowing firms to manage coordination of interdependent activities.

Conventional approaches to interfunctional coordination appeared in management literature include direct contact and mutual adjustment, integrative departments, and cross-functional teams [9, 17, 24, 30]. Regarding the coordination of production and marketing activities in specific, the related literature suggests the use of the following approaches : devising an appropriate reward system [28, 31], developing proper organizational coordination tools [10, 29, 33], using decision support tools [5], and utilizing integrated data and knowledge bases [15].

From the decision-making perspective, many studies have been conducted to provide implications of using different approaches to solving the problems occurring at the PM interface [7]. Given the fact that many firms handles production and marketing subproblems *separately* in spite of their close relationships [11, 16], many researchers have suggested the use of the joint strategy to combine subproblems into one grand model and jointly solve it [6, 13, 20, 32, 35].

While it is expected to provide a superior performance, the joint strategy has its own shortcomings. It does not necessarily yield optimal decisions due to the complexity of the joint model. Furthermore, the joint approach is impractical for functionally decentralized firms because the joint strategy simply ignores coordination issues arising at the interface of PM.

To overcome these problems of the joint strategy, we in the present study adopt a more realistic point of view. We propose an IT-Based Coordination System (ITBCS) which aims to provide decision and coordination support for production and marketing to find optimal allocation of the common resources between the two functions and among multiple products. ITBCS extends PROMISE [22], an IT-based PM coordination mechanism for a single product, in order to handle the resource-constrained multiproduct case. As in PROMISE, ITBCS utilizes two types of the single-product coordination strategy by Kim and Lee [14] - MDCA (Marketing Dominating Coordination Approach) and PDCA (Production Dominating Coordination Approach).

We first identify convergence problems of MDCA and PDCA and present a refined coordination strategy for the single product case that dynamically switches between MDCA and PDCA to overcome the convergence problems. Then, utilizing the Lagrangean dual approach [2], we devise a coordinated decision support scheme for the multi-product case with limited resource availability. This scheme yields the optimal resource allocation decisions for the entire firm while granting individual departments with the freedom of seeking locally optimal decisions at the functional level.

Lee and Cho [18] propose a Web-based version of PROMISE [22] with a computational improvement of the coordination mechanism by Kim and Lee [14]. However, the approach by Lee and Cho does not offer the multi-product and resource allocation capabilities. These capabilities of ITBCS make a significant contribution to the PM interface literature because the joint and coordinated approaches reported in the literature fail to handle the multi-product case. We implement the multi-product coordination mechanism for the distributed computing environment where geographically remote production and marketing are electronically wired. With illustrative examples, we show how ITBCS can be used in practice to coordinate PM decisions in a functionally decentralized firm. In addition, we demonstrate that the coordination mechanism of ITBCS can be applied to find optimal decisions for various PM tactical planning problems that have been solved in the literature only by the joint strategy.

Significance of our study can be summarized as follows. First, it proposes a comprehensive coordination mechanism which finds optimal PM decisions under various cost structures such as convex and concave costs. It can also handle various tactical PM planning problems appeared in literature that would be otherwise difficult to solve by the previous coordinated strategy. Second, the proposed coordination mechanism is capable of dealing with the multiple product case, for which, to our best knowledge, there is no optimal approach whether it takes a joint or coordinated strategy. Third, our study develops a prototype for an IT-based information system that works under the LAN environments where production and marketing are physically remote but electronically wired.

The rest of this paper is organized as follows. Section 2 provides a brief review of the PM decision-making literature and proposes a PM coordination mechanism for the single product case that can be used under both concave and convex cost structures. This coordination mechanism is then extended to handle the multiple product case. Section 4 discusses the managerial implications and the issues related to implementation of ITBCS. This paper ends with concluding remarks.

2. Coordination of PM Decision-Making

2.1 Review of The PM Decision-Making Approaches

As mentioned previously, coordination of production and marketing is necessary for a firm to enhance its performance. The key component of the coordinated strategy is a coordination mechanism that guarantees global optimal decisions. Consider a firm whose objective is to determine the demand quantity (D) that will maximize profit defined as follows :

$$\text{(OP)}\ \text{Maximize}_{D}\ \text{TR}(D) - \text{TC}(D) \qquad (1)$$

where total revenue (TR) and total cost (TC) are written as functions of D. Optimality conditions for this overall problem (OP) are i) Marginal Revenue (MR) = Marginal Cost (MC) and ii) MR′ < MC′ where MR′ and MC′ are the first order derivatives of MR and MC, respectively.

The joint strategy assumes a central decision-making authority that has access to all necessary information and makes cross-functional decisions. In this case, the firm would solve (OP) directly and there is little need for coordination in terms of decision-making.

Details of a coordination mechanism depend on how to achieve MR = MC while making sure that MR′ < MC′ is satisfied. To facilitate discussion, consider a PM tactical planning problem where the firm desires to make marketing mix and production/inventory decisions. For this problem, Kim and Lee [14] proposed two coordination approaches : MDCA and PDCA. With MDCA, marketing and production solve their subproblems iteratively. The marketing subproblem (MP) and production subproblem (PP) under MDCA are expressed as follows.

$$(\mathrm{MP}_{\mathrm{mdca}})\ \mathrm{Maximize}_{D_t}\ \mathrm{TR}(D_t(m_t), m_t) - \mathrm{MC}_{t-1} \cdot D_t \tag{2}$$

$$(\mathrm{PP}_{\mathrm{mdca}})\ \mathrm{Minimize}_{X_t, u_t}\ \mathrm{TC}(X_t, u_t) \quad \text{subject to } X_t = D_t \tag{3}$$

where m_t is the marketing mix, and X_t and u_t are the production quantity and production schedule at iteration t, respectively. Based on MC_t calculated by production, marketing finds the profit-maximizing demand D_{t+1} and send it to production. Production then computes MC_{t+1}, and the process of exchanging D and MC between marketing and production continues until it converges to a certain set of decisions.

When MDCA fails to converge to an optimal solution, Kim and Lee [14] further suggest to use PDCA in which the following production and marketing subproblems are iteratively solved :

$$(\mathrm{PP}_{\mathrm{pdca}})\ \mathrm{maximize}_{X_t, u_t}\ \mathrm{MR}_{t-1} X_t - \mathrm{TC}(X_t, u_t) \tag{4}$$

$$(\mathrm{MP}_{\mathrm{pdca}})\ \mathrm{maximize}_{m_t}\ \mathrm{TR}(D_t, m_t) \quad \text{subject to } D_t = X_t \tag{5}$$

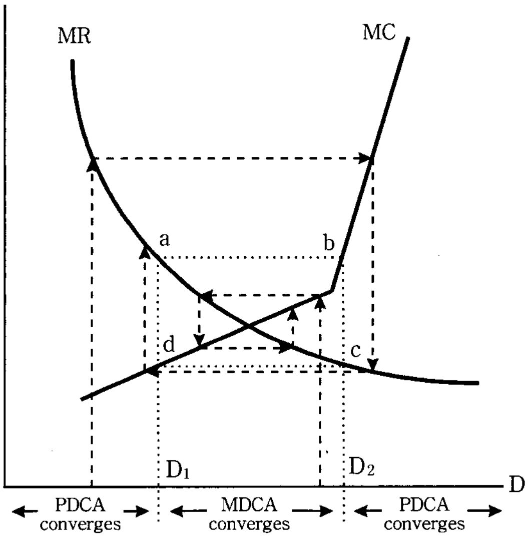
Production uses the marginal revenue (MR) information from marketing to determine the production quantity X_t.

The convergence conditions of MDCA and PDCA are as below [14] :

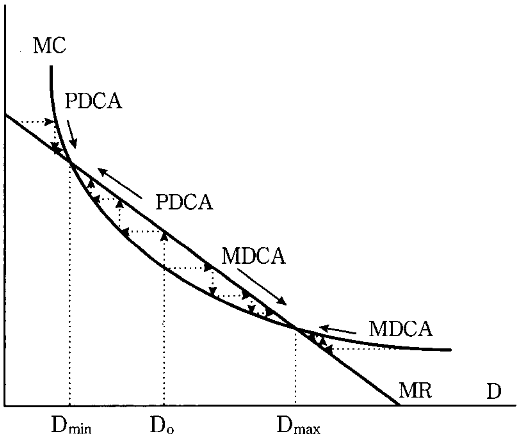
1) MDCA converges if $|\mathrm{MR}'| > |\mathrm{MC}'|$ and
2) PDCA converges if $|\mathrm{MR}'| < |\mathrm{MC}'|$.

2.2 Developing a Comprehensive Coordination Mechanism : Single-Product Case

Although Kim and Lee [14] make a significant contribution to literature, their theoretical results should be further refined if they are to be implemented in real settings. From the implementation perspective, we need to devise a more comprehensive coordination mechanism that can handle different cases. In order for MDCA and PDCA to be directly applicable, the corresponding convergence conditions must be satisfied globally, i.e., over the possible range of D. The slopes of MR and MC curves however change as we move along the curves. It is very likely that the convergence condition of MDCA (or PDCA) is satisfied around the optimal demand D^* while the convergence condition of PDCA (or MDCA) becomes satisfied as we move away from D^*. This case is graphically shown in [Figure 1] where MDCA converges to D^* within the range $D_1 < D < D_2$, outside of which PDCA converges. If the process is started with PDCA outside the range $D_1 < D < D_2$, it will converge up to a certain point and then get stuck, oscillating between D_1 and D_2 and forming a rectangle abcd (see [Figure 1]). When this happens, a proper coordination mechanism would break away from this "oscillation rectangle" by jumping inside the rectangle. We call this "perturbation" of the process. After perturbation, the coordination mechanism should switch the coordination approach to MDCA for convergence.



[Figure 1] Convergence Conditions Locally Satisfied



[Figure 2] Coordination by Switching between MDCA and PDCA : Concave TC

[Figure 2] also depicts a case where the approach of Kim and Lee [14] cannot be directly applied. They implicitly assume that MR and MC curves intersect at only one point that is the maximum of the overall profit function. This assumption is valid if the TC function is convex. However, if the TC function is concave, the profit functions may have more than one extreme point. In this case, the simple approach of employing either MDCA or PDCA may only obtain a minimum point or a local maximum point. For the sake of convenience, we assume that the range of economically feasible D is known, say (D_L, D_U), within which the optimal D^* is located. This assumption is realistic one because the decision maker with enough experience about the decision-making problem would be highly likely to know the range.

Our coordination mechanism is essentially a search algorithm that never fails to finds all extreme points sequentially, moving from D_L to D_U. Convergence toward an extreme point depends on selection of appropriate coordination approaches (MDCA or PDCA). Once an extreme point has been reached, the coordination mechanism breaks away from it by "perturbation." The mechanism "perturbs" the process by adding a small number (ε) to the current D so that it can bypass the extreme point. It then selects an appropriate coordination approach to move toward the next extreme point. The coordination mechanism we propose can handle any possible variations of the cases discussed above. <Table 1> shows a pseudo-code list of the proposed coordination mechanism that we call Single-product Coordination Mechanism (SPCM).

〈Table 1〉 Pseudo-code list of the single-product coordination mechanism (SPCM)

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Step 0. Set iteration counter $t = 0$ and initialize other parameters. Determine convexity or concavity of the TC function. If convex, go to step 1 (Convex_Module). Otherwise, step 2 (Concave_Module).
Step 1. [Convex_Module] Let $\Delta_t = 0$ and METHOD = MDCA. Go to step 1.t.1.
    step 1.t.1 Set $t = t+1$. Apply METHOD, calculate $\Delta_t = D_t - D_{t-1}$, and check if $|\Delta t| < |\Delta_{t-1}|$. If $|\Delta_t| > |\Delta_{t-1}|$, go to step 1.t.2. Otherwise, go to step 1.t.3.
    step 1.t.2 The process diverges. Switch METHOD by setting METHOD = PDCA and go to step 1.t.1.
    step 1.t.3 Check if $|\Delta_t| - |\Delta_{t-1}| \approx 0$. If so, go to step 1.t.4. Otherwise, go to step 1.t.1 for the next iteration.
    step 1.t.4 Check if $\Delta_t \approx 0$. If so, we have found the optimal point and thus stop. If not, the process is "oscillating." Perturb the process by $D_t = (D_t + D_{t-1})/2$ and go to step 1.t.1.

Step 2. [Concave_Module] Let $D_t = D_L$ and METHOD = MDCA. Go to step 2.t.1.
    step 2.t.1 Set $t = t+1$. Apply METHOD and check if $\Delta_t = D_t - D_{t-1} > 0$. If $\Delta_t < 0$, go to step 2.t.2. Otherwise, go to step 2.t.3.
    step 2.t.2 "Moving backward ($D_t$ decreases)" and thus switch METHOD (from MDCA to PDCA or vice versa). Set $D_t = D_{t-1}$ and go to step 2.t.1.
    step 2.t.3 Check if $\Delta_t \approx 0$. If so, go to step 2.t.4. Otherwise, go to step 2.t.1 for the next iteration.
    step 2.t.4 A new extreme point has bee found. If $D_t < D_U$, record the information about the extreme point, and go to step 2.t.5. Otherwise, all the extreme point between $D_L$ and $D_U$ has been found. Determine the optimal $D^*$ by comparing the profits at $D_L$, $D_U$, and all the extreme points found so far, and stop.
    step 2.t.5 To bypass the current extreme point ("perturbation"), set $D_t = D_t + \varepsilon$ and switch METHOD. Go to step 2.t.1 to find the next extreme point.
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SPCM provides a comprehensive coordination framework for handling many PM decision-making problems in literature that have been solved only by the joint strategy [1, 19, 20, 21, 27]. <Table 2> shows reformulation of the past PM decision-making models that used the joint strategy. <Table 2> presents production and marketing subproblems to be solved by MDCA and PDCA, and these subproblems are the models that would be included in the model bases of the production and marketing DSSs of ITBCS. Although calculus and nonlinear program solvers are sufficient for the solution of the production and marketing subproblems in <Table 2>, other solution techniques may be required for the individual DSSs for other types of PM tactical planning problems.

〈Table 2〉 Application of Coordination Approaches to Single-Product Models

Reference	Overall Problem (OP)	Subproblems for MDCA	Subproblems for PDCA
Freeland [8]	$\max_{p,m,x}\ pD(p,m) - m - C(D,x)$ where $D = dp^{-\alpha}m^{\gamma}$, $C(D,x) = a_iD + b_iD^2$ for $x = i\ (i = 1, 2)$	(MP) $\max_{p,m}\ pD(p,m) - m - MC_oD(p,m)$ (PP) $\min_x\ C(D_o, x)$	(MP) $\max_{p,m}.\ pD_o(p,m) - m$ (PP) $\max_{D,x}\ MR_oD - C(D,x)$
Porteus [27]	$\max_{p,q,s}\ pD(p) - cD(p) - sD(p)/q - hcq/2 - hA_s(s)$ where $D = a - bp$, $A_s(s) = As^{-\lambda} - F$ for $0 < s \leq s_1$	(MP) $\max_{p,D}\ pD(p) - MC_oD(p)$ (PP) $\min_{q,s}\ sD_o/q + hcq/2 + hA_s(s)$	(MP) $\max_p\ pD_o(p)$ (PP) $\max_{q,s,D}\ MR_oD - cD - sD/q - hcq/2 - hA_s(s)$

〈Table 2〉 Application of Coordination Approaches to Single-Product Models (Continued)

Reference	Overall Problem (OP)	Subproblems for MDCA	Subproblems for PDCA
Lee [19]	$\max_{p,q}\ pD(p) - c(q)D(p) - sD(p)/q$ $- hc(q)q/2$ where $D = dp^{-\alpha}$ and $c = uq^{-\beta}$	(MP) $\max_p pD(p) - MC_o D(p)$ (PP) $\min_q\ c(q)D_o + sD_o/q$ $+ hc(q)q/2$	(MP) $\max_p\ pD_o$ (PP) $\max_{D,q}\ MR_o\ D - c(q)D$ $- sD/q - hc(q)q/2$
Lee and Kim [20]	$\max_{p,q,M}\ pD(p,M) - MD(p,M)$ $- c(D)D(p,M) - sD(p,M)/q$ $- hC(D)q/2$ where $D = kp^{-\alpha}M^{\gamma}$ and $C = uD^{-\delta}$	(MP) $\max_{p,M}\ pD(p,M)$ $- MD(p,M) - MC_oD(p,M)$ (PP) $\min_q\ c(D_o)D_o + sD_o/q$ $+ hc(D_o)q/2$	(MP) $\max_{p,M}\ pD_o\ (p,M)$ $- MD_o(p,M)$ (PP) $\max_{D,q}\ MR_o\ D - c(D)D$ $- sD/q - hc(D)q/2$
Lee, Kim, and Cabot [21]	$\max_{p,q,r}\ pD(p) - c(D)D(p)/r$ $- sD(p)/(qr) - hc(D)qr/2 - hK(r)$ where $D(p) = dp^{-\alpha}$, $c(D) = uD^{-\delta}$, and $K(r) = k_1r^{\varepsilon} - k_2\ (\varepsilon > 1)$ for $r_1 \le r \le 1$.	(MP) $\max_p pD(p) - MC_o D(p)/r_o$ (PP) $\min_{q,r} c(D_o)D_o/r$ $+ sD_o/(qr) + hc(D_o)qr/2$ $+ hK(r)$	(MP) $\max_p\ pD_o$ (PP) $\max_{D,q,r} MR_oD - c(D)D/r$ $- sD/(qr) - hc(D)qr/2$ $- hK(r)$

Nomenclature

p	price
m	promotion expense per unit
M	total promotion expense
D(•)	demand as a function of •
C(•)	total production cost as a function of •
c(•)	unit production cost as a function of •
h	inventory carrying rate per one dollar per year or cost of capital
α	price elasticity of demand
β	quantity discount factor
δ	economy of scale factor
γ	promotion elasticity of demand
q	lot size
s	setup cost per setup
r	process reliability
A(s)	setup reduction investment function
K(r)	investment function for process reliability improvement

2.3 Extension To The Multi-product Case

It is more realistic to assume that a firm has multiple products whose production and sales activities require consumption of common resources. Consider that the firm has one common resource to allocate to n different products so that the total profit from sales and manufacture of the n products is maximized. Then, the overall problem (OP) for the firm can be written as below.

$$\max\ \pi = \sum_{i=1}^{n} \pi_i = \sum_{i=1}^{n} [\mathrm{TR}_i\,(D_i,\, m_i) - \mathrm{TC}_i(D_i,\, u_i)]$$

$$\text{subject to } \sum_{i=1}^{n} \mathrm{F}_i(D_i) \le R \qquad (6)$$

$F_i(D_i)$ determines the amount of the common resource consumed by product i. The constraint indicates that there are R units of the common resource available. Without loss of generality, we assume the single common resource case because the approach to be presented below can clearly handle the multiple resource case.

By placing the constraint into the objective function with a nonnegative Lagrangean multiplier μ, we obtain the Lagrangean problem.

$$\begin{aligned} \mathrm{L}(\mu) &= \max_{D_i, m_i, u_i} \sum_{i=1}^{n} \mathrm{L}_i(D_i, m_i, u_i) + \mu R \\ &= \sum_{i=1}^{n} [\mathrm{TR}_i\,(D_i, m_i) - \mathrm{TC}_i\,(D_i, u_i) \\ &\quad - \mu \mathrm{F}_i(D_i)] + \mu R \end{aligned} \qquad (7)$$

Note that the Lagrangean problem decomposes into n independent subproblems. Solving the following Lagrangean dual problem is equivalent to solving (OP).

$$\min_{\mu} \quad \mathrm{L}(\mu) \tag{8}$$

where $\mu \geq 0$.

The multiplier μ represents the unit price of the constrained resource. For a given μ, the Lagrangean subproblem of maximizing $\mathrm{L}_i(\mathrm{D}_i, \mathrm{m}_i, \mathrm{u}_i)$ for each i corresponds to the (OP) of the single-product case. Presented below are the production and marketing subproblems to be solved for each i under the MDCA and PDCA.

MDCA

$$\begin{aligned} &\text{Marketing : } \max_{D_{i,t},\, m_{i,t}} \mathrm{TR}_i(D_{i,t}, m_{i,t}) - \mu \mathrm{F}_i(D_{i,t}) - \mathrm{MC}_{i,t-1} D_{i,t} \\ &\text{Production : } \min_{X_{i,t},\, u_{i,t}} \mathrm{TC}_i(X_{i,t}, u_{i,t}) \\ &\qquad \text{subject to } X_{i,t} = D_{i,t} \end{aligned} \tag{9}$$

PDCA

$$\begin{aligned} &\text{Production : } \max_{X_{i,t},\, u_{i,t}} \mathrm{MR}_{i,t-1} X_{i,t} - \mathrm{TC}_i(X_{i,t}, u_{i,t}) \\ &\text{Marketing : } \min_{D_{i,t},\, m_{i,t}} \mathrm{TR}_i(D_{i,t}, m_{i,t}) - \mu \mathrm{F}_i(\mathrm{D}_{i,t}) \\ &\qquad \text{subject to } X_{i,t} = D_{i,t} \end{aligned} \tag{10}$$

Solving the production and marketing subproblems by SPCM of <Table 1> yields the optimal production and marketing decisions (D_i, m_i, X_i, u_i) for a given μ. At the η th iteration, we obtain the optimal decisions $(D_i^{\eta}, m_i^{\eta}, X_i^{\eta}, u_i^{\eta})$ for all i and the resulting profit π^{η} by applying SPCM repeatedly. These new results are then used in forming the following linear program called the master problem, in order to find the new resource price μ :

$$\begin{aligned} &\min_{w,\mu} \ w \\ &\text{subject to } w \geq \pi^{\eta} + \mu\Big(R - \sum_{i=1}^{n} \mathrm{F}_i(D_i^{\eta})\Big) \\ &\qquad \eta = 0, 1, 2, \cdots, \mathrm{T}-1 \quad \mu \geq 0 \end{aligned} \tag{11}$$

where T is the number of iterations so far. Let w^{η} and μ^{η} be the optimal objective value and the optimal multiplier value of the master problem at iteration η. Given μ^{η}, the Lagrangean subproblems are solved by SPCM to find the new optimal objective value (L^{η}) and decisions $(D_i^{\eta}, m_i^{\eta}, X_i^{\eta}, u_i^{\eta})$.

The iterative process of solving the master and Lagrangean subproblems ends when the next stopping condition is met :

$$\{\mathrm{Min}_{1 \leq \eta \leq T} \mathrm{L}^{\eta}\} - w^{T} \leq \varepsilon \tag{12}$$

where ε is a numerical tolerance level. Note that L^{η} provides an upper bound and w^{T} a lower bound. Therefore, when they become sufficiently close enough, the solution process terminates. The multi-product coordination mechanism (MPCM) can be summarized as below.

Step 0. Set the iteration counter $\eta = 0$ and find an initial feasible solution for all i.

Step η.1 Let $\eta = \eta + 1$. Solve the master problem and obtain the optimal multiplier μ^{η}. Go to step η.2.

Step η.2 Solve the Lagrangean subproblem for $\mathrm{L}(\mu^{\eta})$ by applying SPCM for each i. Stop if the stopping condition is met. Otherwise, go to Step η.1. Repeat the process until the stopping condition (12) is satisfied.

3. IT-Based Coordination Systems

3.1 Background

In the field of management, over the past two decades, many business firms have invested heavily in IT to improve their management performance. Consequently, computers are ubiquitous in the work place and the associated changes are apparent in goods and services in terms of highly improved quality and speed. Indeed, major management activities are based on IT. Therefore, modern management can be called IT-based management (ITBM).

The ITBCS approach can be considered as one of spin-offs from ITBM, which applies IT to develop a more realistic coordination mechanism. Therefore, the implications of ITBCS can be clarified by the discussions on the current trend of ITBM. Computer networks are a key success factor in ITBM, for they can provide the links for the rapid dissemination of data. Typical computer networks are Internet, Local Area Networks (LANs), Wide Area Networks (WANs), and combination of them. Typical applications of ITBM can be found in marketing, production, and finance. Marketing applications of ITBM include those that provide good cost benefits as well as rapid access to marketing database securing the potential for a company to gain competitive strength [34]. For example, EDI (Electronic Data Interchange)-based order entry systems, POS (Point-Of-Sale) data entry combined with EFT (Electronic Fund Transfer) system, computerized reservation systems, and electronic commerce [23, 26]. Financial applications of ITBM are crucial to modern financial services firms. For example, both on-line service and ATM (Automatic Teller Machine) are essential components. Also EFT enables sending payment instructions all over the world via WANs or Internet. Especially, EFT combined with POS can yield a drastic improvement in marketing performance [34]. All the transactions in Wall Street would have been simply impossible without enormous computing power of ITBM. For instance, a single deposit account enables customers to access to mutual funds, automatic deposits and withdrawals, and ATMs. Production applications of ITBM can provide accessibility to computer networks for managing the design, manufacture, and delivery of goods. Manufacturing firms now use Flexible Manufacturing Systems (FMS), Computer Aided Design/ Computer Aided Manufacturing (CAD/ CAM), EDI, Just-In-Time (JIT) to increase their quality, flexibility, and responsiveness [4, 23, 34].

The patterns are similar in other industries. ITBM delivers far more value per dollar spent, yielding a competitive advantage. Recent research on the economic contribution of IT to consumer welfare shows that IT investments generate approximately three times their cost in value for customers [3]. Based on the discussions so far, we can argue that the ITBCS approach can practically secure a more realistic and viable option for coordinating PM.

3.2 Implementation

ITBCS is based on the coordination mechanism proposed in section 2. It consists of three computing nodes that are networked together via microcomputers : a first representing the coordination mechanism, and a second and a third being for production DSS and marketing DSS.

ITBCS has been implemented on Microsoft Excel environment with the Visual Basic Macro code. With the experimental settings of ITBCS, locally optimal production and marketing decisions are found by their respective individual DSSs which are both running on Microsoft Excel, wired to LAN, and controlled by ITBCS. The SPCM of ITBCS controls the individual DSS. Through LAN, ITBCS calls each DSS on the other PCs and instructs them which models (subproblems) to be solved and which information to be communicated. ITBCS has been implemented in such a way that the Solver library in Excel, which utilizes the nonlinear programming solver GRG2, is automatically called in to solve the individual subproblems of production and marketing and the master problem of MPCM.

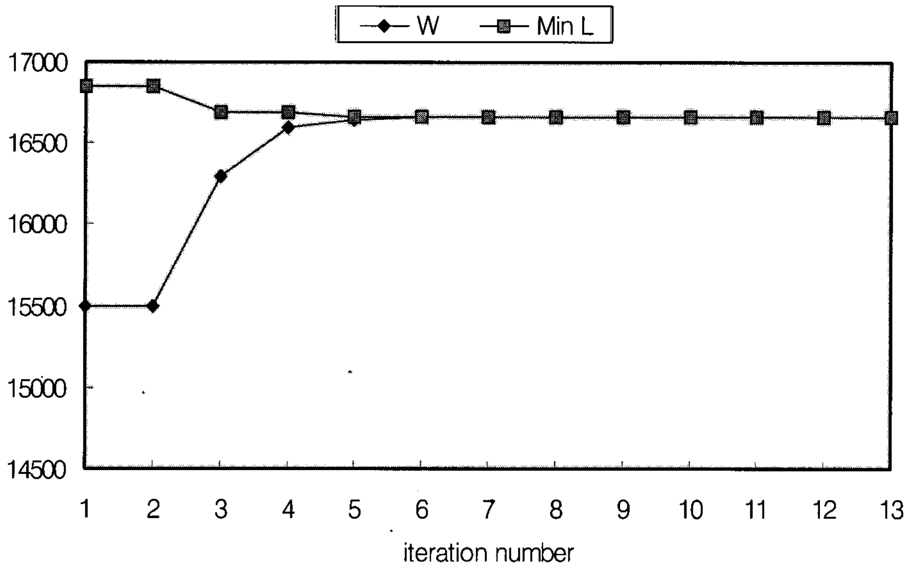
To illustrate how ITBCS operates, we use a

〈Table 3〉 Illustration of the Solution Process

Iter. no.	Prod. ID	Lot					Resource used	Total Profit	Lagr. Mult.	w	Min. of L
		Price	Prom.	Size	Dem	Profit					
0	1	25.73	1.93	178	667	10827.91					
	2	8.77	0.58	298	667	1673.85					
	3	16.13	0.97	149	667	2993.97	2000.00	15495.72			
1	1	16.92	1.27	263	1448	11975.49			0	15495.729	
	2	8.90	0.59	292	638	1674.95					
	3	19.28	1.16	121	438	3198.15	2524.33	16848.59			16848.595
2	1	23.14	1.74	197	811	11275.33			2.5801	15495.729	
	2	13.68	0.91	160	192	1250.05					
	3	24.30	1.46	92	254	2991.54	1257.76	15516.91			16848.595
3	1	19.45	1.46	231	1119	11813.64			1.0514	16297.311	
	2	10.84	0.72	222	368	1550.41					
	3	21.33	1.28	107	346	3152.34	1832.32	16516.38			16692.680
4	1	18.08	1.36	247	1281	11936.69			0.4800	16596.880	
	2	9.79	0.65	256	490	1641.50					
	3	20.22	1.21	114	392	3187.40	2163.30	16765.58			16687.188
5	1	18.73	1.41	239	1199	11886.31			0.7529	16642.631	
	2	10.29	0.69	238	426	1602.29					
	3	20.75	1.24	111	369	3173.17	1994.10	16661.78			16666.224
· ·				· ·							
10	1	18.71	1.40	239	1202	11888.22			0.7440	16666.171	
	2	10.27	0.68	239	428	1603.72					
	3	20.73	1.24	111	370	3173.72	1999.27	16665.65			16666.194
11	1	18.70	1.40	239	1203	11889.17			0.7395	16666.191	
	2	10.26	0.68	239	429	1604.43					
	3	20.72	1.24	111	370	3173.99	2001.87	16667.58			16666.194
12	1	18.71	1.40	239	1202	11888.66			0.7419	16666.193	
	2	10.27	0.68	239	428	1604.05					
	3	20.73	1.24	111	370	3173.84	2000.48	16666.54			16666.194
13	1	18.71	239	1202	1202	11888.33			0.7435	16666.194	
	2	10.27	239	428	427.88	1603.80					
	3	20.73	111	370	369.69	3173.75	1999.58	16665.88			16666.194

Note) Input Parameter (R=2000)

prod.	α	γ	d	s	c	h	υ
1	2	0.15	400.000	50	7	0.3	1
2	3	0.2	500.000	100	5	0.3	1
3	2.5	0.15	700.000	50	10	0.3	1



[Figure 3] The Convergent Process by MPCM

multi-product version of Kim and Lee [12] in <Table 2>. The Appendix shows the details of the model formulations for the overall problem and production and marketing subproblems under MDCA and PDCA. <Table 3> presents the solution process along with the input parameters for the numerical example. [Figure 3] graphically illustrates the rapidly convergent process by ITBCS for the example.

3.3 Discussion

Through the implementation of ITBCS, the following implications are obtained when compared with the previous joint approaches [5, 6, 13, 19, 32, 35].

(1) More timely decisions can be made due to more rapid communication and more readily achieved consensus.

(2) More appropriate and higher-quality coordinated decisions can be made due to better and quicker joint access to required data and improved opportunities to analyze data in a rapid joint access to information.

(3) Coordinated decisions will tend to bring higher levels of commitments and actions from production and marketing, yielding higher quality and quantity outputs.

(4) Coordination of the PM decision-making process will minimize human interference, eliminating the chance for politics involvement.

(5) Coordination process between production and marketing can be made independent of geographical distance because necessary information is rapidly and easily transferred to each other through computer networks.

A successful implementation of ITBCS will require full consideration of several practical issues. Lack of communication due to functional barriers tends to be aggravated by the geographical separation. Language difference may worsen the situation if production and marketing are located in different countries. The use of IT-based coordination systems such as ITBCS will not only facilitate prompt and accurate communication but also reduce the need for direct communication by automatically transferring data required for PM decision-making. A more realistic ITBCS would run on TCP/IP protocol, considering the fact that the use of Internet as a main computer network grows exponentially in the fields of ITBM.

Top management as well as production and marketing managers must be committed to achieving the corporate goal. This means the corporate goal supersedes the functional goals. Production and marketing managers need to understand the importance of granting the priority to the corporate goal over the functional goals. Furthermore, developing and enforcing reward systems that induce functional cooperation becomes an essential element of interdependence management.

Because different coordination approaches such as MDCA and PDCA require different functional objectives, switching between them as in ITBCS may turn out to be confusing to the functional groups. For example, production under MDCA must minimize production costs but its objective changes to profit maximization under PDCA. This may be quite unconventional and clearly deviate from the traditional concept of production being responsible for cost. Rationale behind this unconventional idea should be clearly understood by all relevant parties including top management. Equally unconventional is that production determines the sales volume under PDCA. This may appear quite unnatural of marketing to accept because controlling demand through various marketing planning has been traditionally marketing's role in many firms.

Furthermore, necessary data may not be available, and this may hinder successful implementation of the system like ITBCS. Even if data are available, each function may not be willing to exchange truthful information during the coordination process due to lack of motivation to do so. Design of an appropriate reward system becomes critical in preventing information distortion.

4. Concluding Remarks

Significance of the ITBCS approach is three-fold. First, it provides a unifying solution mechanism for single-period marketing/production decision-making problems appeared in literature. Different solution methods are required to analyze variations or extensions of (OP). Second, the previous solution methods, except for Freeland [8], are all taking the joint strategy, not applicable to functionally decentralized firms. Therefore, the ITBCS approach may be the only viable option currently available for solving the problem of coordinating PM decisions in functionally decentralized firms. Under the assumption of functionally decentralized firms, ITBCS is conceptually designed to link two distributed DSSs via the coordinated strategy and to provide a more realistic guidance for coordinating PM decisions. Third, ITBCS can handle the multi-product case which is certainly a more realistic situation than the single product case. ITBCS opens up the possibility of applying the IT-based DSS concept with the coordinated strategy to a broader class of PM decision-making coordination problems that have been solvable so far only by the joint approaches.

〈Appendix〉 : The PM Coordination Problem Formulation for the Illustrative Example

The numerical example we used is based on the multi-product version of the single-product case without economy of scale ($\delta = 0$) considered by Lee and Kim [20].

$$\max \sum \pi_i = \sum (P_i D_i - m_i D_i - c_i D_i - s_i D_i / Q_i - h_i c_i Q_i) \qquad \text{(A1)}$$

$$\text{subject to } \sum v_i D_i \le R \qquad \text{(A2)}$$

where $D_i = d_i p_i^{a_i} m_i^{\gamma_i}$. By placing the constraint into the objective function with the Lagrangean multiplier μ, we obtain the following Lagrangean problem which can be easily solved by the SPCM.

$$\max \sum (P_i D_i - m_i D_i - \mu v_i D_i - c_i D_i - s_i D_i / Q_i - h_i c_i Q_i / 2) + \mu R \qquad \text{(A3)}$$

MDCA

Marketing subproblem :

$$\max \sum [P_i D_i - m_i D_i - (\mu v_i + MC_i) D_i] \qquad \text{(A4)}$$

Production subproblem :

$$\min \sum (S_i X_i / Q_i - h_i c_i Q_i / 2) \qquad \text{(A5)}$$

$$\text{subject to } X_i = D_i \text{ for all i.} \qquad \text{(A6)}$$

PDCA

Production subproblem :

$$\max \sum MR_i X_i - (\mu v_i + c_i) X_i - s_i X_i / Q_i - h_i c_i Q / 2 \qquad \text{(A7)}$$

Marketing subproblem :

$$\max \sum P_i D_i - m_i D_i \qquad \text{(A8)}$$

$$\text{subject to } D_i = X_i \text{ for all I} \qquad \text{(A9)}$$

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